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Remarks

Claims 1-12 are currently pending in the present patent application, with claim 13 having been cancelled through the above claim amendments. Claim 1 has been amended to more particularly point out and distinctly claim the recited subject matter. This amendment does not narrow the scope of claim 1.

In a final Office Action mailed 5 June 2006, the Examiner maintained the rejections of claims 1-6, 9, and 11-12 under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent Application Publication No. 2002/0164523 to Shibata *et al.* ("Shibata"). Claims 7-8 and 10 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Shibata in view of U.S. Patent Application Publication No. 2002/0028367 to Sammes *et al.* ("Sammes").

On September 7, 2006, the undersigned along with the inventor Partho Sarkar and Brian Y. Lee, Canadian counsel for the assignee of the present application, held a telephone interview with the Examiner to discuss the rejections of the pending claims. As set forth in the Examiner's Interview Summary mailed September 12, 2006, no agreement was reached as to the allowability of any of the claims. More specifically, with regard to claim 1, the Examiner contends that the alumina ceramic of the Shibata reference corresponds to the porous ion-conducting structure recited in claim 1. See page 3 of the Interview Summary. The Examiner contends that even if the alumina ceramic is considered in the prior art as an insulating material, this material is nonetheless capable of conducting some ions, even if such ion conductivity is poor. *Id.* The Examiner requested objective evidence to support that such an alumina ceramic is "incapable" of transporting ions, meaning that the material exhibits no ion conduction at all. *Id.* During the interview, the Examiner also raised what he termed a potential 35 U.S.C. § 112, paragraph 1, issue regarding the recitation of an ion-conducting structure in the claims and pointed to paragraph 19 of the specification to support his assertion that only a description of oxygen ion conducting materials is contained in the application.

In order to help the Examiner appreciate certain distinctions between the pending claims and the subject matter of the applied references, a disclosed embodiment of the invention will now be discussed in comparison to the applied references. Specific distinctions between the pending claims and the applied references will be discussed after the discussion of the disclosed embodiment and the applied references. This discussion of the differences between the disclosed embodiment and applied references does not define the scope or interpretation of any of the claims.

Embodiments of the present invention are directed to an anode-supported solid oxide fuel cell (SOFC) including an anode support layer. A suitable material for the anode support layer (ASL) is yttria stabilized zirconia (YSZ). See, e.g., paragraph 8 of the present application. YSZ is an excellent conductor of negatively charged oxygen (oxide) ions at high temperatures. See paragraph 3. A SOFC operates at an elevated temperature, typically in the order of between 700-1000 °C. *Id.* YSZ is a solid oxide electrolyte and an oxygen ion conductor suitable for use in a SOFC. See, e.g., page 101 of the Suresh publication, which accompanies this amendment as Attachment 1. Other oxygen ion conducting materials suitable for use in a SOFC may be substituted for YSZ in the anode support layer. See paragraph 19. A characteristic of a solid electrolyte, which may otherwise be known as a fast ion conductor or a superionic solid, is a high electrical conductivity in the range of 10^{-1} - 10^{-4} ohm⁻¹ · cm⁻¹ (i.e. a resistivity of 10-10,000 ohm · cm). See page 17 of Attachment 1. In contrast, alumina (aluminum oxide) has a resistivity of 5.0×10^8 at 700°C and 2×10^6 at 1000°C (see page 959 of the Shackelford and Alexander publication, which accompanies this amendment as Attachment 2) and thus is not a solid electrolyte/fast ion conductor/superionic solid suitable for SOFC use. See also the article that accompanies this amendment as Attachment 3 for additional information regarding resistivity and the listing of Web sites in Attachment 4 that illustrate alumina being used as an insulator.

Turning now to the Shibata patent, the Examiner points to paragraph 69 of Shibata as disclosing an SOFC unit cell having a porous base body 1 which

includes a ceramic (alumina) body plated with Ni, an electrode 10, an electrolyte 12, and an electrode 11. The base body 1 material (alumina) simply cannot be considered a porous oxygen ion conducting structure suitable for solid oxide fuel cell use. As shown in accompanying samples of scientific literature, alumina's resistivity is too high for this material to be considered a solid electrolyte and an oxygen ion conductor suitable for use in a SOFC. In order for a material to be considered an oxygen ion conductor suitable for SOFC use in an electrode, the material must provide the necessary and efficient ionic path for anodic reaction which takes place during SOFC operation. As is well known in the SOFC art, the ionic conductivity of the anode must be comparable to the ionic conductivity of the electrolyte, and thus alumina's resistivity is also too high at SOFC operating temperature to carry out SOFC electrode function.

The Examiner cannot contend that because alumina must exhibit some ion conductivity, the base body 1 of Shibata may be considered to correspond to the anode support layer of the present application. Materials are classified as having physical characteristics that result in each material being placed in a particular class of materials, such as an electric or thermal conductor or insulator or an ionic conductor or insulator. Materials are not classified in absolute terms as is suggested by the Examiner. The Examiner requests evidence that "ceramic alumina is INCAPABLE of transporting ions (no ion conduction at all)." See page 3 of the Interview Summary. No such evidence can be provided for any material. Although classified as a particular type of material, every material will exhibit some characteristics of another class of materials. For example, materials classified as electrical insulators exhibit some amount of electrical conductivity, but such conductivity is so small that these materials are nonetheless classified as insulators. If the Examiner's argument was accepted, then the classification of materials would be rendered pointless. Any material could be said to be whatever type of material was needed by an Examiner when formulating a rejection.

Pursuant to MPEP § 2111, during patent examination the pending claims must be given their broadest reasonable interpretation consistent with the

specification. The Examiner expressly mentioned this well known tenet of patent examination. As expressly set forth in Section 2111, the "broadest reasonable interpretation of the claims must also be consistent with the interpretation that those skilled in the art would reach." As evidenced by the accompanying technical literature, as well as the comments of the inventor Partho Sarkar during the telephone interview with the Examiner, one skilled in the art would not interpret the phrase "ion-conducting structure" to include the insulating material of alumina ceramic. The Examiner's attempt to so interpret this phrase is simply put an unreasonable interpretation of this language. Although the Examiner cites the "broadest reasonable interpretation" language of Section 2111 as the rationale for his interpretation, such an interpretation of this language plainly in violation of this section of the MPEP as well as in contravention of common sense.

Now turning to the claims, amended claim 1 recites an anode-supported solid oxide fuel cell including an anode support layer. The anode support layer includes a porous oxygen ion-conducting structure suitable for solid oxide fuel cell use and having pores impregnated with a catalytic and electronically conductive material. An electrolyte layer is in adjacent intimate contact with the anode support layer and a cathode layer is in adjacent intimate contact with the electrolyte layer.

Shibata neither discloses nor suggests an anode support layer as recited in amended claim 1. The base body 1 of Shibata simply cannot be said to correspond to the recited anode support layer. As discussed above, an alumina ceramic as set forth in paragraph 69 of Shibata simply is not "a porous oxygen ion-conducting structure suitable for solid oxide fuel cell use." Because an alumina ceramic exhibits some ion conductivity does not make such an alumina ceramic an ion-conducting structure. As previously discussed with reference to the attached technical literature, alumina's resistivity is too high for this material to be considered a solid electrolyte and an oxygen ion conductor suitable for use in a SOFC. Such an alumina's resistivity is also too high at SOFC operating temperatures to carry out the function of an SOFC electrode.

Furthermore, claim 1 recites an electrolyte layer in intimate contact with the ASL. Shibata discloses electrodes 10 and 11 to be in intimate contact with the electrolyte, and neither electrode 10, 11 of Shibata corresponds to the structure of the ASL as recited in claim 1, i.e. a porous oxygen ion conducting structure suitable for SOFC use and having pores impregnated with a catalytic and electronically conductive material. Although the Examiner suggests that the porous base body 1 in Shibata discloses the ASL as presently claimed, such base body is not in intimate contact with the electrolyte, nor can the base body material (alumina) be considered a porous oxygen ion conducting structure suitable for solid oxide fuel cell use.

For all these reasons, the combination of elements recited in amended claim 1 is allowable. Dependent claims 2-11 are allowable for at least the same reasons as claim 1 and due to the additional limitations added by each of these claims.

It should be pointed out that amended claim 1 now expressly recites that the anode support layer includes a "porous oxygen ion-conducting structure." Support for this is found, for example, in paragraph 12 of the application. This amendment should render moot any potential Section 112 issues alluded to by the Examiner in the Interview Summary. See page 3 of the Interview Summary. These comments are not meant to indicate that the undersigned agrees there ever were any Section 112 deficiencies with the prior claim language. Also note that this amendment in no way necessitates a new search by the Examiner since, as admitted by the Examiner, the prior language could have been construed to include any type of ion-conduction structure so surely the prior search included oxygen ion-conducting structures. The same is true of the amendment that the oxygen ion-conducting structure is "suitable for solid oxide fuel cell use." This amendment merely expressly recites what was implicit before and is in direct contrast to the structure and function of the relied upon components in Shibata, which are not suitable for solid oxide fuel cell use." The same is true for the amendments of claim 12, which will now be discussed in more detail below.

Amended claim 12 recites an anode-supported solid oxide fuel cell comprising an anode support layer including an oxygen ion-conducting structure suitable for solid oxide fuel cell use and with a plurality of vias extending through the thickness of the oxygen ion-conducting structure. At least some of the vias are filled with electronically conductive material. An anode functional layer is in adjacent intimate contact with the anode support layer and an electrolyte layer is in adjacent intimate contact with the anode functional layer. A cathode layer is in adjacent intimate contact with the electrolyte layer.

Shibata neither discloses nor suggests an anode support layer as recited in amended claim 12. The base body 1 of Shibata simply cannot be said to correspond to the recited anode support layer since an alumina ceramic is not an oxygen ion-conducting structure suitable for solid oxide fuel cell use. Simply because an alumina ceramic exhibits some ion conductivity does not make such an alumina ceramic an ion-conducting structure. Alumina's resistivity is too high for this material to be considered a solid electrolyte and an oxygen ion conductor suitable for use in a SOFC and the resistivity is also too high at SOFC operating temperatures to carry out the function of an SOFC electrode.

For all these reasons, the combination of elements recited in amended claim 12 is allowable.

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The present patent application is in condition for allowance. Favorable consideration and a Notice of Allowance are respectfully requested. The Examiner is requested to contact the undersigned at the number listed below for a telephone interview if, upon consideration of this amendment, the Examiner determines any pending claims are not in condition for allowance. The undersigned also requests the Examiner to direct all future correspondence to the address set forth below in the event the Examiner shows a different correspondence address for the attorney of record.



Respectfully submitted,

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Attachment 1

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*super-
ionic
solids* PRINCIPLES
AND
APPLICATIONS

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CHAPTER 2

Superionic Materials and Structures

Superionic solids are ionic materials with high electrical conductivity comparable with those of liquid electrolytes. These materials are also termed "solid electrolytes" or "fast ion conductors". Typically a superionic solid has the following characteristics:

- (i) crystal bonding is ionic;
- (ii) electrical conductivity is high ($10^{-1} - 10^{-4} \text{ ohm}^{-1} \text{ cm}^{-1}$);
- (iii) principal charge carriers are ions which means that the ionic transference number (t_{ion}) is almost equal to 1 (here t_{ion} refers to the fractional contribution of the ionic conductivity to the total conductivity);
- (iv) the electronic conductivity is small; generally materials with electronic transference number (t_e) less than 10^{-4} are considered satisfactory superionic solids.

The values of electrical conductivity of a few ionic and superionic solids are shown in Figure 2.1. The highest conductivity at room temperature obtained so far is for RbAg_4I_5 which is $0.27 \text{ ohm}^{-1} \text{ cm}^{-1}$. This is many orders of magnitude higher than those of the more commonly known ionic solids KCl , NaCl etc. which have room temperature conductivity $\sim 10^{-12} - 10^{-16} \text{ ohm}^{-1} \text{ cm}^{-1}$. It may be noted that most of the superionic materials attain a high electrical conductivity above a certain temperature which may or may not be well defined. In other words, with increasing temperature the electrical conductivity sometimes changes gradually (as in β -alumina) or shows an abrupt jump (e.g. in β - AgI , RbAg_4I_5 etc.). Furthermore, for the latter materials the abrupt conductivity change is sometimes associated with a distinct structural change (like the $\beta \rightarrow \alpha$ transition in AgI) but sometimes this is not so clear (as in RbAg_4I_5). Structures which allow fast ion transport are generally disordered, "channelled" or "layered" (Wiedersich and Geller 1971). Ion-Ion interactions or correlation

over, Owens (1971) has noted that M^+ ions with volumes greater than $85(\text{\AA}^3)$ do not generally form conductive compounds. Furthermore, for bigger cations a lesser amount may be needed. For example, the maximum conductivity is obtained with 13 mole % MI for the $(\text{CH}_3)_4\text{NI}-\text{AgI}$ system, 12.5 mole % in the $(\text{CH}_3)_2(\text{C}_2\text{H}_5)_2\text{NI}-\text{AgI}$ system and 12 mole % in the $(\text{C}_2\text{H}_5)_4\text{NI}-\text{AgI}$ system. This means that the percentage of added cations decreases with its increasing size as is expected from Raleigh's picture.

The above structural principles have been deduced on the basis of the very small amount of available structural data — mostly on cation substituted systems. More structural studies would be necessary both on anion and cation substituted systems to arrive at a better understanding.

2.8 Oxygen ion conductors

The first solid oxide electrolyte ever used was probably the ceramic with composition 85 wt % ZrO_2 , 15 wt % Y_2O_3 which was used by Nernst (1899) as an incandescent lighting material. Later Baur and Preis (1937) used this material for a fuel cell. The definite conductivity mechanism in terms of oxygen vacancies was proposed by Wagner (1943) and later verified by Hund (1952). However, the sudden increase of scientific interest in such materials started after Kiukola and Wagner (1957a, 1957b) illustrated their use in high-temperature thermodynamic measurements and fuel cells. In principle, almost all oxides can be expected to show some degree of oxygen ion conduction particularly the non-stoichiometric oxides. The non-stoichiometry can be created by heating the metal oxides in vacuum or oxygen or the relevant metallic vapour (Wagner 1974). Most of the oxygen ion conductors are good only at high temperatures ($\sim 1000^\circ\text{C}$) and are mixed conductors (ionic + electronic + electron-hole). As in the case of other ionic conductors, the conductivity in this case is strongly dependent on the temperature and doping with aliovalent impurities (like Ca^{2+} , Y^{3+} , Sr^{2+} etc. in HfO_2 , CeO_2 etc.) which control the number of point defects and their mobility. However, a unique property of oxide conductors is the dependence of the conductivity on the ambient pressure or activity. If the ambient oxygen pressure is low, the oxygen ions (O_O) would leave the solid electrolyte according to the following mechanism†:

† The defects are expressed in the Kröger-Vink notation: the symbol indicates the defect; the subscript the location of the defect; and the superscripts (') (') denote negative and positive charges respectively. For example $V_\text{O}^{\bullet\bullet}$ means vacancy at the oxygen site having effectively two positive charges. Similarly, $\text{O}_\text{i}^{\bullet\bullet}$ would indicate an oxygen ion at the interstitial site with effectively two negative charges.

tions, cooperative hopping or correlation effects play important roles. Details of the conductivity mechanism will be discussed in Chapter 4. Figure 2.46 gives a schematic plot of conductivity as a function of partial pressure of ambient oxygen for a typical oxide electrolyte at three different temperatures. The higher the temperature, the lower is the range of oxygen pressure over which the conductivity is ionic. The dependence of the range of ionic conduction on concentration of aliovalent dopant (like Ca^{2+} or Y^{3+}) is shown in Figure 2.47. The effect of increasing concentration is to broaden the range of ionic conductivity and shift the whole conductivity curve to lower p_{O_2} values.

Most of the useful oxide electrolytes developed so far are based on ThO_2 , CeO_2 , HfO_2 and zirconia, though some other systems have also been described. For an earlier review see Etsell and Flengas (1970). The common structure which sustains high oxygen ion conduction is the "fluorite structure". The fluorite structure for MO_2 (M = metal ion Th, Ce etc) is shown in Figure 2.48. In this structure there are a large number of octahedral interstitial voids. Each metal cation is surrounded by eight

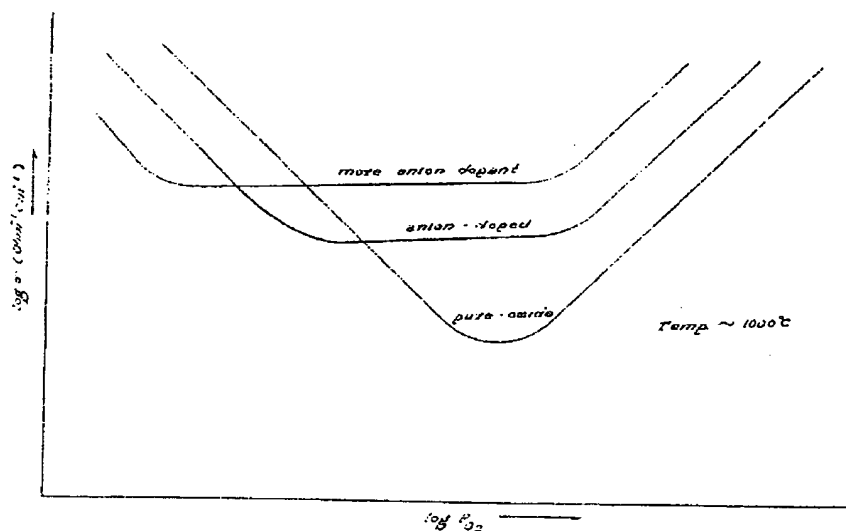


Fig. 2.47 Schematic representation of the dependence of conductivity of any oxide ion electrolyte on oxygen partial pressure for samples doped with different concentrations of aliovalent anion (Ca^{2+} , Y^{3+} etc.).

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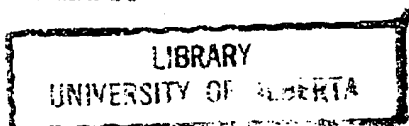
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Attachment 2

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**MATERIALS SCIENCE
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THIRD EDITION

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and
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Electrical Properties**Table 291. RESISTIVITY OF CERAMICS**

(SHEET 4 OF 6)

Class	Ceramic	Resistivity (Ω -cm)	Temperature Range of Validity
Oxides	Aluminum Oxide (Al_2O_3)	$>10 \times 10^{14}$	25°C
		2×10^{13}	100°C
		1×10^{13}	300°C
		6.3×10^{10}	500°C
		5.0×10^8	700°C
		2×10^6	1000°C
	Beryllium Oxide (BeO)	$>10^{17}$	25°C
		$>10^{15}$	300°C
		$1-5 \times 10^{15}$	500°C
		$1.5-2 \times 10^{15}$	700°C
		$4-7 \times 10^{15}$	1000°C
	Magnesium Oxide (MgO)	1.3×10^{15}	27°C
		$0.2-1 \times 10^8$	1000°C
		4×10^2	1727°C
	Silicon Dioxide (SiO_2)	10^{18}	room temp.
	Zirconium Oxide (ZrO_2)		
	(stabilized)	2300	700°C
	(stabilized)	77	1200°C
	(stabilized)	9.4	1300°C
	(stabilized)	1.6	1700°C
	(stabilized)	0.59	2000°C
	(stabilized)	0.37	2200°C

Source: data compiled by J.S. Park from No. 1 Materials Index, Peter T.B. Shaffer, Plenum Press, New York, (1964); Smithells Metals Reference Book, Eric A. Brandes, ed., in association with Palmer Research Institute Ltd. 6th ed. London, Butterworths, Boston, (1983); and Ceramic Source, American Ceramic Society (1986-1991).

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Attachment 3

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Summary of Comments on Steele

Page: 1

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editorial review articles

Materials for fuel-cell technologies

Dorian C. H. Starks & Angela K. Hatzivelli

Einige der hier veröffentlichten Ergebnisse der Untersuchung sind in der Zeitschrift *Zeitschrift für Vergleichende Sprachwissenschaft* 1972, 116 (1972) veröffentlicht.

Erweiterte Fingerringechnik. Universität Potsdam, Februar 1981. 2077 Banden (inzwischen abstrahiert)

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The search for conversion of the nuclear energy into electrical energy for its positive first half was that of "thermonuclear" war. Half a year ago, however, in the wake of the atomic bomb, the second half of the nuclear energy conversion was the subject of a new international literature, and with this new technology, it has proved difficult to develop the early scientific experiments that common daily viable nuclear power plants require. These problems have often been solved with the lack of appropriate materials or manufacturing techniques that would enable the cost of electricity per kWh to be comparable with the existing technology, as utilized in a power plant, for example.¹

[illegible]

Although the rationale for a "top-down" approach seems to be sound, results at the corporate level have been mixed. Technical and cost innovations have been slow to develop, and even cost reductions have been modest. The major barrier to product innovation is the lack of funding for research and development. In fact, according to a recent survey, which was published in *Business Week*, the average R&D investment as a percentage of sales for the top 100 U.S. companies is only 1.9 percent, compared with 2.5 percent for the top 100 Japanese companies. The survey was by Sullivan and Zeitz (see page 23-24).

One of the reasons for the lack of funding for research and development is a breakdown in the relationship between the government and the private sector. The government has been reluctant to fund research and development in the private sector, and the private sector has been reluctant to fund research and development in the government. This has led to a situation where the government is not funding research and development in the private sector, and the private sector is not funding research and development in the government. This has led to a situation where the government is not funding research and development in the private sector, and the private sector is not funding research and development in the government.

varies considerably in the letters influencing the organization of the cells.

Conclusions on Computer Software

[illegible]

structural per MW in their substituted. The higher, and more uniform, efficiency values are associated with the higher molecular weights of the substituted polymers (Fig. 1). In the intermediate range of molecular weights, the substitution and processing of the cell components are not sufficient to obtain a high efficiency. The best efficiency of 10.6% was obtained for a polymer with a molecular weight of 100,000. The efficiency decreased for the test time only about 50 days after the fabrication of the solar cells. The efficiency of the solar cells was found to be stable for more than 100 days. The efficiency of the solar cells was found to be stable for more than 100 days. The efficiency of the solar cells was found to be stable for more than 100 days.

[illegible]

High-molecular-weight (HMW) poly(amide-imide)s were prepared by the polycondensation of 4,4'-thiobis(2-chlorobenzoic acid) (TBCA) with various diamines, phthalic anhydride, and tertiary amines. The polycondensation was carried out in *N*-methyl-2-pyrrolidone (NMP) with appropriate charge ratios. The ASR values of these polycondensates can be roughly calculated by the following basic specific hydroxyl values in the TBCA system can be calculated by the following equation:

"

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Insight review articles

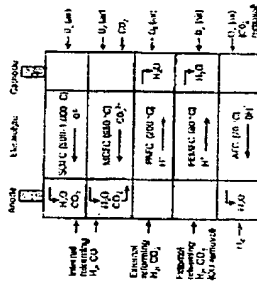


Figure 1 summarizes three cell types. The weighted molecular weight (M_w) of the polymer is the linear sum of the molecular weights of the components: $M_w = 100 + 200 + 300 = 600$. The number-average molecular weight (M_n) is the sum of the molecular weights of the components divided by the number of components: $M_n = (100 + 200 + 300)/3 = 200$. The degree of polymerization (DP) is the ratio of the molecular weight of the polymer to the molecular weight of the monomer: $DP = 600/100 = 6$. The number-average degree of polymerization (DP_n) is the ratio of the number-average molecular weight to the molecular weight of the monomer: $DP_n = 200/100 = 2$. The weight-average degree of polymerization (DP_w) is the ratio of the weight-average molecular weight to the molecular weight of the monomer: $DP_w = 600/100 = 6$. The polydispersity index (PDI) is the ratio of the weight-average molecular weight to the number-average molecular weight: $PDI = 600/200 = 3$. The polydispersity index is a measure of the molecular weight distribution of the polymer. A PDI of 1 indicates a monodisperse polymer, while a PDI greater than 1 indicates a polydisperse polymer. The PDI of 3 indicates a broad molecular weight distribution.

[illegible]

the electronic control loop of the plant. The fact that the three functions are performed by the same hardware is a major advantage, since such a design allows the third order to be implemented with relatively small costs. The fact that the three functions are performed by the same hardware also has the advantage of reducing the risk of errors in the design of the control system, since the three functions are performed by the same hardware.

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Additional constraints influencing material selection are: local availability and the ability to build. For transport applications, minimal weight of performance is desired (for example, 0.1% over 1,000 lbs are rewarded for projected operating lifetimes of 8,000 h). But for software applications – (for example, distributed CJP) – (condensed heat and power) systems – a smaller degradation rate is most valued over a period of at least 48,000 h (5 years). Therefore lifetime weight need to be limiting problems for PEMFC-powered CJP systems. As the stack components were developed to lightly for transport applications.

A mixed-effects, between-subjects, within-between, design (Hartmann et al., 2009) was used to compare values, error variances, and fitting. Although these hierarchical components comprise at least half the cost of the level-1 system, we will use computer simulations to compare the cost of the level-1 system with the cost of the level-2 system. We used the *nlme* package for the R programming language (R Core Team, 2013) to fit the PIVC system using data from which there were no improvements for participants appearing less than 100,000 h in the study (sample of typical medical residents) as well as between 100,000 and 200,000 h (sample of experienced residents). We also included a third level, the level of the individual physician, to account for the subject of intensive, deep-learning within the work, and a variety of unmodeled, repeatable, between-subjects differences. We modeled the use of components or sub-components of the system as fixed effects, and the impact of practice task autonomy within the aspect of the work as a random effect.

For more than four decades now, reliable, efficient, fuel-cell-type systems incorporating APCs have provided the portable power for spacecraft and space stations. Together, these systems, when operating on pure hydrogen and oxygen, are an extremely fast way to generate electricity. However, the use of APCs in the development of this system, but for the intended application, the additional expense, reliability, and weight that must be added to the system by larger hydrazine or alcohol tanks, have provided some problems for materials selection and the associated fuel-processing technology. After 20 years' development, the Hefu Consortium announced attempts in 1996 to develop a system powered by an APC system. Although Zvezda never purchased the technical rights to these patents, that major penetration of APC systems will be small. In spite of a recent problem with the initial flight test of APC systems on a small satellite, the possibility of substituting the use of APC systems with ammonia as the main source of hydrogen fuel is still a possibility.

Asymptotically 200 PACE systems (representing 200 MW) have been installed. Cells (HFC) PACE systems, comprising 200 MW, have been installed around the world and have established great reliability. However, as the commercial lifetime of this system is mostly, in longevity as the manufacturers (HFC and Logicon companies) have been unable to reduce the capital cost sufficiently below US\$5,000 per kW, an artificially forecasted, total capacity will be below US\$5,000 per kW, and the target cost per kW must be reduced to around US\$3,000 per kW, falling to below US\$1,500 per kW, with mature production. Accordingly, we focus here on minimum capital costs of the PACE, PACE, and SOFC systems which, at present, all appear

It is important to note that the materials currently being used in P-APFC, APCFC and tubular SOFCs primarily for demonstration units (approximately 2000 cells per unit) are not the same as those selected at least 25 years ago for the first generation of SOFCs. Although manufacturing issues have hampered the widespread use of advanced materials, the materials used in the first generation SOFCs were not the best for the job. The materials used in the first generation SOFCs were not the best for the job. The materials used in the first generation SOFCs were not the best for the job.

Polymorphic electrolyte membranes find wide use in the most important materials under development for PEMFC stacks are conventional materials for the cell bases, bipolar plates, and electrolyte as for the fuel and air electrode, and the bus conducting materials.

Depositing on the fluid to be used in the PEM cell, the requirements for these materials are completely different. The simplest case is the operation with pure hydrogen as oxidant gas and air as oxidant gas.

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Editorial review articles

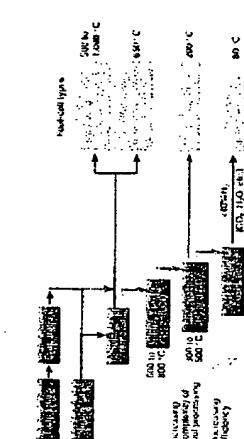


Figure 2. Effect of pH and ionic strength on the adsorption of Cu^{2+} on the surface of the polymer. The adsorption of Cu^{2+} on the surface of the polymer was measured at different pH values and ionic strengths. The adsorption of Cu^{2+} on the surface of the polymer was measured at different pH values and ionic strengths. The adsorption of Cu^{2+} on the surface of the polymer was measured at different pH values and ionic strengths.

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Important R&D target. However, an operation temperature above the boiling point of water requires a completely different type of membrane material, as no liquid water will be present under those circumstances for the hydrated protonic conduction mechanism.

تذکرہ

More effort is being expended on the development of cost-effective plastic materials for the liquid phase. With respect to corrosion resistance, plastic materials are preferred. However, the availability of plastic materials is limited to that of the available materials. Some conducting materials are *e.g.* polymers—15 cm; graphite, 10 to 25 cm; 40,000 to 100,000; the pellets 3,000 to 5,000; 17,240 to 10⁵ g; 5 mm; for bipolar plates, polyimide/graphite composites are developed with at least 10⁵ cm², reducing the resistivity of the bipolar plate will be below the resistivity of this membrane. In addition, the fabrication costs of graphite, plastic, glass, ceramic, and carbon fiber are high, making such composites (not expensive). Moreover, as graphite materials are porous, a binder or resin has to be added to produce the necessary mechanical stability.

Polymers must be machinable, and the ability to be machined is a key to their use. For example, an inherent quality of graphite is its ability to achieve excellent electrical conductivity. Higher contents of graphite produce better electrical conductivity values, but the associated machinability problems make them more undesirable as the increased brittleness not only reduces the toughness, but also makes machining more difficult and expensive. Typical carbon contents range between 30 and 80 weight%, and several groups^{1,2} are optimizing the machining processes in more difficult machinability of the material.

Another step is to use metallurgical plates. The general flow of construction can easily be illustrated with metal foil packaging, but only a few metals are sufficiently corrosion-resistant in the mobile environment at the marketplace. The most promising materials are aluminum, stainless steel, as the nitide, candidate metal and as an alternative, titanium, titanium and gold (including gold-plated metal) are too expensive. Stainless steel can provide satisfactory performance for several thousand hours. The steel is generally by a positive layer of aluminum, which is the most effective corrosion-resistant layer outside of products.

Stainless steel metallurgical plates have been developed by Nucor and by Siemens.

The second important problem is associated with the electrocatalysis. Four experiments with pure hydrogen and air, platinum as the catalyst and an anion-exchange membrane as the electrolyte, have been carried out. To reduce the cost, membranes of polytetrafluoroethylene (PTFE) have been used. The results are shown in Table 1. The results show that the use of PTFE membranes is not very promising. The reason for this is that the PTFE membrane is not very permeable to hydrogen and oxygen. The use of a membrane of polyethylene glycol (PEG) is more promising. The results are shown in Table 2. The results show that the use of PEG membranes is more promising than the use of PTFE membranes. The reason for this is that the PEG membrane is more permeable to hydrogen and oxygen. The use of a membrane of polyethylene glycol (PEG) is more promising than the use of PTFE membranes. The reason for this is that the PEG membrane is more permeable to hydrogen and oxygen.

polymerization of the monomer. It was found that the rate of polymerization was not affected by the concentration of the monomer, but it was affected by the concentration of the initiator. The rate of polymerization was found to be proportional to the square root of the concentration of the initiator. This is a characteristic feature of a free radical polymerization mechanism. The polymerization was found to be exothermic, and the heat of polymerization was found to be approximately 100 kJ/mol. The molecular weight of the polymer was found to be in the range of 10,000 to 100,000. The polymer was found to be soluble in a variety of solvents, including water, methanol, and acetone. The polymer was found to be stable in air and in the dark, but it was found to be sensitive to light and heat. The polymer was found to be biocompatible and non-toxic, and it was found to have a wide range of applications in the field of polymer science.

Insight review articles

insightful reaction between the DSM network and electricity. Selection of the catalyst (SM) and anode (Ni-YSZ) compositions was critical during the 1990s by Westinghouse and ABB, after which the YSZ stack was the responsibility for long-term competition. The Siemens-Westinghouse (SW) design remains the most widely used, but the YSZ stack was the responsibility for long-term competition. The Siemens-Westinghouse (SW) design remains the most widely used, but the YSZ stack was the responsibility for long-term competition.

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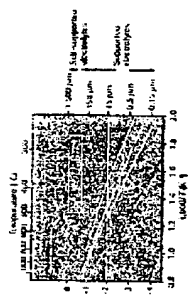


Figure 1: A graph showing the relationship between the operating temperature (T) and the power density (P) for a fuel cell. The x-axis is labeled 'T (K)' and ranges from 1000 to 1300. The y-axis is labeled 'P (W/cm²)' and ranges from 0 to 2.0. The curve shows a sharp increase in power density as temperature increases, starting around 1100 K and reaching a peak of approximately 1.8 W/cm² at 1250 K. The curve is labeled 'Fuel cell' and 'Operating temperature'.

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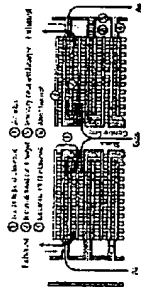


Figure 1. Schematic diagram of the fuel cell system. 1. Fuel inlet, 2. Air inlet, 3. Fuel manifold, 4. Air manifold, 5. Fuel distributor, 6. Air distributor, 7. Fuel collector, 8. Air collector, 9. Fuel outlet, 10. Air outlet.

with the reduction and oxidation of the H_2 component. As the hydrogen is oxidized, the electrons are transferred to the external circuit, and the protons are transferred to the oxygen. The oxygen is then reduced to water, and the protons are transferred back to the hydrogen. This process is repeated continuously, generating a steady flow of electricity.

Most fuel cells are designed to operate at temperatures between 100°C and 1000°C. The operating temperature affects the efficiency and the rate of the electrochemical reactions. Higher temperatures generally lead to higher efficiencies, but they also increase the risk of degradation and the need for more expensive materials.

There are several types of fuel cells, each with its own advantages and disadvantages. Proton exchange membrane (PEM) fuel cells are the most common type, but they require expensive platinum catalysts. Solid oxide fuel cells (SOFCs) are more efficient and have longer lifetimes, but they operate at very high temperatures. Direct methanol fuel cells (DMFCs) are simpler and easier to use, but they have lower efficiencies.

Although fuel cells are still in the early stages of development, they have the potential to revolutionize the way we generate and use energy. As research and development continue, fuel cells may become a viable alternative to fossil fuels and renewable energy sources.

continues into the long-term evolution of a well-defined H_2 fuel cell, which may exhibit higher power densities than the traditional PEM fuel cell. In principle, the use of a well-defined H_2 fuel cell as a power source for a fuel cell system is well known. It is well known that the power density of a fuel cell system is determined by the power density of the fuel cell and the power density of the power source. The power density of a fuel cell system is determined by the power density of the fuel cell and the power density of the power source. The power density of a fuel cell system is determined by the power density of the fuel cell and the power density of the power source.

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Table 2 Summary of known DOE requirements for fuel cell systems

Program	Year	Fuel	Power	Efficiency	Cost	Notes
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE
DOE	2003-2005	H ₂	1-10 kW	40-60%	\$1000/kW	DOE

just had performance. This, for example, is the strategy adopted recently by the US Department of Energy for the Solid State Energy Conversion Alliance, which aims to mass produce 500 W SOFC modular stacks with a target cost of US\$400 per kW. Once this small-scale technology has demonstrated its reliability and met cost targets, then larger units based on the same technology can be expected to penetrate other sectors of the stationary power and transport markets.

Another area requiring increased attention is the development of fuel cell systems for use in portable power. The development of batteries capable of keeping up with the specific power demands of mobile devices, innovative DMFC designs, advanced energy storage devices for the vehicle-to-grid industry, portable energy storage devices (e.g., 1 W in transistors) and other low power devices, for example, could provide a useful market entry for fuel cell technology.

1. DOE, "Solid State Energy Conversion Alliance," DOE, 2003.
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20. DOE, "Solid State Energy Conversion Alliance," DOE, 2003.

Attachment 4

4

Spar Plug use alumina since it is electrically insulator:

<http://vshsp.en.alibaba.com/search/offer>

Auto Ignition System use alumina since it is an insulator:

<http://starsparkplug.en.alibaba.com/offerlist.html>

Alumina insulating coating:

<http://www.freepatentsonline.com/6844023.html>

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Ortech industry -table containing alumina 's properties:

<http://www.ortechceramics.com/alumina.htm>

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Alumina use in thermocouple assembly as a insulator:

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elements, elements with insulators or assemblies. A typical assembly includes a head, alumina insulators and a protecting ...
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Page 8 -shows use of alumina tube in an assembly as a Insulator:

Henry Rohrs poster

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Alumina Insulator. Nickel Seat. Gold O-Ring. SS O-Ring Seat. Vespel Support. Sapphire Ball. PZT Bimorph. Pulsed Valve. The pulsed valve consists of a ...
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Goodfellow- a table listing volume resistivity of alumina >10¹⁴ ohm-cm.:

<http://www.azom.com/details.asp?ArticleID=2103>

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